Chapter 34
Using Fuzzy Goal Programming with Penalty Functions for Solving EEPGD Problem via Genetic Algorithm

Mousumi Kumar
Aghorekamini Prakashchandra Mahavidyalaya, India

Valentina E. Balas
University of Arad B-dul Revolutiei 77, Romania

Bijay Baran Pal
University of Kalyani, India

ABSTRACT

This chapter presents how the concept of penalty functions is incorporated within the framework of Fuzzy Goal Programming (FGP) for modelling and solving Economic-Environmental Power Generation and Dispatch (EEPGD) problems by employing genetic algorithms. In model formulation, first penalty functions to measuring membership values of defined fuzzy goals are presented. Then, minsum FGP method is used to obtain rank based solution in imprecise environment. In the process of solving the problem, a GA scheme is implemented at two different stages. At the first stage, optimal solutions of objective functions are determined for fuzzy representation of each of them. At the second stage, evaluation of achievement function to arrive at the highest membership value of fuzzily described objective goals is taken into account. The standard IEEE 6-Generator 30-Bus test system is considered to illustrate the approach. A comparison of model solution with the solutions of conventional approaches is also made to highlight the potential use of the approach.

INTRODUCTION

Electric power generation is the process of generating electricity from natural sources of energy. Historically, the fundamental principle of electricity generation was initiated by the famous British scientist

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Michael Faraday in the early 1830s.The demand of electricity has increased remarkably in society owing to sustainable growth of human amenities across the globe in the world.

It is worth mentioning here that the thermal power plants are the main supply source of electric energy, where coal is used as a major resource to generate thermal power. But, uses of such resources produce atmospheric pollutants, like Carbon oxides (CO_x), Sulfur oxides (SO_x) and oxides of Nitrogen (NO_x), which are the most harmful pollutants. However, the increase in power generation by burning considerable amount of coal leads to discharging more pollution to earth's environment than any other single industry. Again, the different ways of producing electricity vastly contribute various impacts to the living environment. The major environmental pollutions linked with power plant operations are degradation of bio-diversity, water contamination, and other issues of environment. Further, it is worthy to note that the effort of generating more thermal power is motivated in an increasing rate to meet high rate of demand in recent years by ignoring various hazards owing to discharge of pollutions to the earth's environment. Again, sudden increase in power supply may create massive power failure, which affects extensively the sensitive issues of electric power system. Eventually, appropriate plan for economic power generation and dispatch as well as controlling of environmental pollution are the main issues concerning operations of thermal power plants to meet power demand in society.

The thermal power plant operation and management are actually optimization problems with various objectives and system constraints for generation of power to meet the needs in society.

The mathematical programming (MP) model for power plant operation was introduced by Dommel, & Tinney (1968). The deep study made on thermal power optimization problems in the past century was surveyed by Momoh, El-Hawary, & Adapa (1999). The MP model for minimization of power plant's emissions was first studied by Gent, & Lament (1971).

Now, it is to be mentioned that the problem of power generation and dispatch (PGD) is a multiobjective decision making (MODM) problem. The goal programming (GP) (Ignizio, 1976) method as a target-oriented approach for multiobjective decision analysis in crisp environment and based on the satisficing philosophy of Simon (1945) has been successfully implemented to PGD problems by Abido (2003) and others in the past. But, study in the field is yet to be documented widely in the literature.

However, in the context of using the convention GP to EEPGD problems and other MODM problems, it is worthy to mention that the primary objective of decision maker (DM) is to minimize the overall deviations from target levels of goals in the decision situation. But, owing to limitation of resources, achievement of aspired levels of all goals is a trivial case in actual practice. To cope with such a situation, marginal relaxations on the target levels of objectives and scaling of different penalties in terms of weights with regard to achievement of goal values in different ranges need be essentially taken into account to make an appropriate solution of the problem. The incorporation of such a conceptual frame in functional form, called *penalty functions*, to GP model as an extended version of it (known as the *goal interval programming*) was initially introduced by Charnes, & Collomb (1972) for making decision with multiplicity of objectives of an optimization problem. The effective use of such an approach to MODM problems was discussed (Minguez, Romero, & Domingo, 1988; Rehman, & Romero,1987) in the past.

Now, in the context of modelling most of the practical decision problems, it is often found that DM is faced with the difficulty of assigning exact values of different model parameters of problems owing to inherent inexactness of parameters themselves and imprecise judgments of human. In such a situation, fuzzy programming (FP) methods (Zimmermann, 1987), which is based on theory fuzzy sets (TFS) (Zadeh, 1965), have appeared to solve imprecisely defined MODM problems. FP approach to EEPGD problems has also been discussed (Miranda, & Saraiva, 1992; Tomsovic, 1992). The FGP (Pal, & Moi-

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